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HIGH VOLTAGE INTERFACE MODULE

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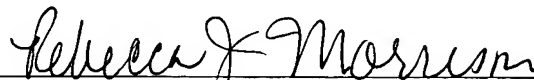
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HIGH VOLTAGE INTERFACE MODULE

TECHNICAL FIELD OF THE INVENTION

[0001]   The present invention relates generally to voltage measurement systems and more particularly, a fail-safe system to measure unsafe voltages remotely by locally conditioning the measured voltages.

BACKGROUND OF THE INVENTION

[0002]   Often complex electronic systems require the measurement of unsafe voltages. These voltages are typically those above 12-15 volts. Prior solutions have attempted to protect equipment and personnel from inadvertent encounters with unsafe voltages. Such encounters can result in electrical shock hazards to personnel, or damage or destruction of electrical circuits or surrounding equipment.

[0003]   A typical solution reduces unsafe voltage with a voltage divider or resistor network. Such a circuit is shown in FIGURE 1. Here an unsafe voltage input 12 is applied to conditioning circuit 10. For illustration purposes, resistor 14 and resistor 16 divide or reduce the unsafe input voltage and provide a reduced output voltage 18 as described by Equation 1:

$$Vout = Vin \frac{R_{16}}{(R_{14} + R_{16})} \qquad \text{(Eq. 1)}$$

Equation 1 shows the ratio by which the unsafe voltage is reduced. Here the unsafe voltage is reduced by the ratio of resistor 16 to the sum of resistor 16 and resistor 14. When resistor 14 has a much bigger value than resistor 16, output voltage 18 is significantly less than the unsafe input voltage 12. However, this simply solution has serious drawbacks. If resister 14 fails in a short circuit condition, output voltage 18 fails to equal voltage of unsafe input voltage 12. This situation can result in high voltages being unexpectedly applied

to circuits and creating a shock hazard to personnel. Similarly, when resister 16 fails open, the output voltage 18 is again equal to the unsafe input voltage 12. Thus, one needs to condition the sampled input voltages with a circuit to provide safe conditioned

5   voltages for measurement purposes. Additionally, these lower voltages are more safely routed through wires or other circuit paths to test the equipment 20.   Any damage to these insulators containing voltages 18 may pose a shock hazard to personnel or surrounding equipment if this voltage is at an unsafe level.

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SUMMARY OF THE INVENTION

[0004]   The present invention provides a high voltage interface system and method that substantially eliminates or reduces disadvantages and problems associated with previously developed voltage sampling methods used to measure unsafe voltages. More specifically, the present invention provides a voltage conditioning interface module to condition an electrical signal locally. This module receives the unsafe electrical signal at an input port. This input port is electrically coupled to an external sampling point on an electrical circuit or system under test.

[0005]   A conditioning circuit having both a voltage reducing circuit and a voltage limiting circuit provides a reduced voltage. The voltage limiting circuit is in parallel with the output terminals that output the reduced voltage. This arrangement ensures that when a circuit element within the voltage reducing circuit fails, an unsafe condition does not exist across these terminals.

[0006]   A first electrical pathway couples the received electrical signal to the conditioning circuit. This pathway typically employs high voltage carriers or leads. A second circuit pathway couples the modules output to a data acquisition or display.

[0007]   In one embodiment, the voltage reducing circuit drops the unsafe voltage across a first resistance and a second

resistance arranged in series. Typically the output terminals

measure the voltage drop across the second resistance.

[0008]   The voltage limiting circuit typically uses a transorb

arranged in parallel to the second resistance. In one

embodiment, the voltage limiting circuit uses a first diode

aligned such that if a voltage across the output terminals

exceeds the diodes breakdown voltage, the output terminals are

shunted to a reference point. A second diode in the circuit is

arranged in parallel to the first diode, but aligned such that

forward current flow in the second diode is opposite that of the

first diode. This arrangement ensures that should the second

resistance fail as an open circuit, the output terminals are

shunted to ground. The voltage limiting circuit guarantees that

a single point failure in either the first resistance or the

second resistance does not result in the reduced voltage output

exceeding a predetermined safe voltage. To enhance safety, the

voltage conditioning circuit may be encapsulated within an epoxy

package.

[0009]   Another embodiment provides method to locally condition

a sample voltage signal. Here, sampling point(s) within a

circuit under test couple via a first circuit pathway to provide

the sampled unsafe-voltage signal to a voltage divider circuit.

This sampling point may be located within a complex system having

a plurality of sampling points coupled to a remote data

acquisition system. Next, the sampled voltage drops across the

voltage divider circuit. A reduced voltage measured across a portion of the voltage divider provides the reduced voltage output. The reduced voltage at the reduced voltage output is prevented from exceeding a predetermined voltage level by a voltage limiting circuit.

[0010]   To facilitate the measurement process, the ratio of reduced voltage to the sampled voltage may be a constant ratio calculated according to Kirchhoff's law. Foe example, the ratio of the second resistance to the sum of the first resistance and the second resistance in one embodiment is about 1/101.01. Additionally, in most applications, the measured electrical signal does not exceed about 600 volts and the reduced voltage does not exceed about 40 volts. The reduced voltage output may then be provided to a data acquisition system or display (meter) through a second circuit pathway.

[0011]   Yet another embodiment provides a voltage interface module to locally condition a potentially unsafe electrical signal sampled from within a complex system. An input port electrically couples to receive the unsafe electrical signal from an external sampling point within the complex system. A conditioning circuit encapsulated within epoxy, contains a voltage divider circuit having a first resistance and a second resistance. The voltage output is taken across the second resistance to provide a reduced voltage output. This voltage is protected from an over voltage condition by a voltage limiting

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circuit arranged in parallel with the second resistance. The

limiting circuit bounds the reduced voltage across the output

terminals when either the first resistance or the second

resistance fails. A second set of electrical leads may couple

5   the output terminals to a data acquisition system or display.

[0012]   The voltage limiting circuit may contain a transorb or

other like device known to those skilled in the art. In another

embodiment, the voltage limiting circuit has two diodes. The

first diode is aligned such that if the reduced voltage across

10   the output terminals exceeds the diode's breakdown voltage, the

output terminals are shunted to a reference point or ground.

[0013]   The second diode is arranged in parallel to the first

diode but is aligned such that forward current flow in the second

diode is opposite that of the first diode. The second diode

15   prevents an unsafe voltage from being applied to the output

terminals when the second resistance fails in any open circuit

condition.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]   For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings in which like reference numerals indicate like features and wherein:

[0015]   FIGURE 1 depicts a prior art method by which the sampled voltage could be reduced;

[0016]   FIGURE 2 provides a circuit that reduces the sampled voltage by a predetermined ratio while providing a guarantee of over voltage protection.

[0017]   FIGURE 3 provides a pictorial view of one embodiment of an interface module taught by this disclosure; and

[0018]   FIGURE 4 describes how the ratio of resistances within the circuit may be determined with a known voltage point and measured voltage output.

DETAILED DESCRIPTION OF THE INVENTION

[0019]   Preferred embodiments of the present invention are illustrated in the FIGUREs, like numerals being used to refer to like and corresponding parts of the various drawings.

5   [0020]   In one embodiment, the disclosure provides a high voltage interface module used to reduce unsafe voltage to safe levels. As illustrated by the circuit contained in FIGURE 2, a high or unsafe voltage input 32 is applied to circuit 30. Input voltage 32, drops across the voltage divider circuit having

10   resistor 34 and resistor 36. The output voltage equals the portion of input voltage dropped across the terminals of resistor 36. The valve equals input voltage 32 reduced by the ratio of resistor 36 to the value of resistor 36 summed with resistor 34.

[0021]   Transorb 38 prevents a failure in either resistor 34 or

15   resistor 36 from resulting in the presence of a shock or other electrical hazard. This hazard would be carried within leads 40 and 42, used to carry the output voltage to test equipments 44. Transorb 38 may comprise a pair of oppositely aligned diodes 46 and 48. When diode 46 breaks down, for example, at 40 volts.

20   Such a condition may occur if resistor 34 were to short-circuit. Similarly, if resistor 36 were to open circuit, the resulting the output voltage across the terminals of resistor 36 would be shunted to the reference point or ground by diode 48. In this condition, terminals 50 and 52 are connected to the reference

25   points where diode 48 shunts input voltage 32.

[0022] This circuit, designed to be installed at or near a high-voltage sampling point, reduces the need to run dangerous high-voltage leads from the sampling point to testing equipment 44. In one example, input voltage 32 is reduced by a ratio of 1/101.01. The output voltage, as previously stated, may be limited by a 40-volt transorb in the event of any signal element failure. The reduced-voltage output, measured across the terminals of resistor 36, runs to a data acquisition system or to a meter (display). As described, this system employs passive components and requires no adjustments or calibration.

Additionally, the described results eliminate the need for high-voltage leads in favor of low-voltage leads 40 and 42. The low-voltage leads carry voltages that do not pose a shock hazard to personnel or an electrical hazard to equipment. This reduces risk associated with testing complex equipment containing high or unsafe voltages and has many industrial applications.

[0023] FIGURE 3 provides an isometric view of one embodiment of a high-voltage interface module. Here leads 60 and 62 couple to sampling points for a high-voltage output. The high-voltage outputs to a circuit functionally equivalent to that described in FIGURE 2. In this case, this circuit is encapsulated within potted box enclosure 64. This enclosure protects technicians working on the circuit. Copper tab 66 serves as the reference or ground of the previously described circuit of FIGURE 2. Low-voltage leads 68 and 70 route the output voltage to data

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collection equipment. The connection passes through electrical
connections 72 and 74.

[0024]   The passive nature of the circuit ensures that once the
circuit is constructed, its functional characteristics may be

5   easily determined by samples a known voltage. FIGURE 4
illustrates that a known voltage input 82 is applied to the
circuit 85. Resistor 86 allows a low-voltage output measurement
to be taken across terminals 88 of resistor 86. The known input
voltage and measured output voltage provide a constant ratio by

10   which all future measurements using this high-voltage interface
module may be ratioed as defined by Equation 2:

$$\frac{V_{out}}{V_{in}} = \frac{R_{36}}{(R_{34} + R_{36})} \qquad (Eq. \ 2)$$

Equation 2 shows the ratio of the low voltage output (V_{out}) to the
Known Voltage Input (V_{in}) equals to the ratio of the value of

15   resistor 86 to the sum of resistors 86 and 84.

[0025]   The empirically determined ratio remains constant over
the life of the interface module and may typically be quickly
determined by the relationship continued in Equation 2. Equation
3 uses the empirically determined ratio of Equation 2 to

20   determine the value of $V_{unknown}$.

$$V_{unknown} = V_{measured} \frac{Vin}{Vout} \qquad (Eq. \ 3)$$

For example, the ratio in Equation 2 may be recorded in data
associated with the individual interface module for later use

when sampling input voltages of an unknown value(s). The

measured voltage is in Equation 3 shows that an unknown high-

voltage input may be easily calculated as the product of a

measured low voltage output ($V_{measured}$) and the inverse ratio

described in Equation 2. The ratio of a known high-voltage input

(V_{in}) to its measured low-voltage output (V_{out}) equals the ratio

of the resistor values.

[0026]   The disclosed voltage interface module provides the

ability to safely sample high-voltage signals and condition those

signals locally at the point of measurement. Then these signals

are routed via low-voltage leads to data collection equipment.

This arrangement avoids potential shock hazards to which previous

high-voltage measurement systems were susceptible. Thus, the

present invention provides a safe and simple means to measure

unsafe voltages in a complex system while protecting equipment

and personnel from inadvertent and unexpected encounters with

high-voltages. This system has numerous industrial applications,

and ensures that should a signal element failure occur, the

output of the interface module remains at a safe voltage level.

[0027]   Although the present invention is described in detail,

it should be understood that various changes, substitutions and

alterations can be made hereto without departing from the spirit

and scope of the invention as described by the appended claims.